

**DEPARTMENT OF TRANSPORTATION****ENGINEERING SERVICE CENTER**

Transportation Laboratory

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**METHOD OF TESTS FOR STEEL REINFORCING BAR BUTT SPLICES**

**CAUTION:** Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section G of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

**A. SCOPE**

The procedures used for determining the adequacy of mechanical butt splices (fabricated on the jobsite for job control tests or as presented by the manufacturer for prequalifying for usage on a highway construction job) for steel reinforcing bars are described in this test method.

**B. TESTING APPARATUS AND ACCESSORIES**

1. A calibrated tension test machine capable of applying a tensile force in excess of the ultimate tensile strength of the reinforcing bars will be satisfactory.
2. A calibrated device, such as an extensometer or caliper, capable of measuring bar slip across the splice to the nearest 25  $\mu\text{m}$  will be satisfactory. Two gauges or reference points, on opposite sides of the bar, shall be algebraically summed and averaged to determine the actual movement in the splice.

3. A device capable of measuring strain (see note 2) in a reinforcement bar to the nearest 25  $\mu\text{m}$  is required.

**C. TEST PROCEDURE****PART I. MECHANICAL BUTT SPLICE  
PRODUCTION/JOB CONTROL TESTS  
(Standard Specification  
Section 52 - 1.08E)**

1. Establish two reference points on opposite sides of the reinforcing bars, one beyond either end of the splice such that slip within the connection can be measured to the nearest 25  $\mu\text{m}$ . Reference punch marks or an extensometer can be used.
2. The span of the extensometer or reference punch marks shall be determined by the bar diameter, coupler length and the deformation pattern where the extensometer is fastened to the reinforcement bar. The distance spanned shall be approximately equal to the coupler length plus 4 bar diameters.
3. For strain measurement, mark two additional sets of reference points on the reinforcing bars on either side of the

splice. These should be outside of the slip reference points and shall span 200 mm. Intermediate divisions are optional. See ASTM A370 Section 10.

4. Mount the sample in the test machine and preload the sample to 4 MPa to set the jaws on the bar ends. Take an initial measurement/reading or zero the dial indicators.
5. Apply an axial tensile load such that the tensile stress in the reinforcing bar equals 200 MPa. When using two dial indicators, watch the direction of needle movement. If the sample splice straightens, one indicator will move in the positive direction and the other may move in the negative direction.
6. Then reduce the load to 20 MPa and again take a reading or measure the distance between the references.
7. Subtract the first measurement from the second measurement and report this difference as "slip". The readings taken from opposite sides of the bar, must be added algebraically and averaged to determine the actual "slip".
8. Remove the extensometer, and apply an axial tensile load to the test specimen sufficient to cause failure.
9. Record load and note location, type of failure, and any necking of the bar.
10. Report maximum load attained as "maximum test load".
11. Measure the strain of the bar on the side of the splice away from the failure. Calculate the percent strain by subtracting the original punch mark spacing from the final punch mark spacing and dividing by the original punch mark spacing, then multiply by 100.

Percent strain =

$$\{ L_{\text{final}} - L_{\text{original}} / L_{\text{original}} \} \times 100$$

12. Report this as the "percent strain."

## **PART II. MECHANICAL BUTT SPLICE PREQUALIFICATION (Standard Specification Section 52 - 1.08C)**

In addition to the above tests perform the following :

13. For strain measurement, mark two sets of reference points on the reinforcing bars on either side of the splice. These should be outside of the slip reference points and shall span 200 mm. Intermediate divisions are optional. See ASTM A370 Section 10.
14. Evaluate a reinforcement splice sample in cyclic loading from 5% to 90%  $f_y$  for 100 cycles. Use a haversine wave form at 0.5 Hz for #36, #43, #57 bars and 0.7 Hz for smaller bars. If failure has not occurred at the end of 100 cycles, increase axial tensile load to cause failure in the sample.
15. Record load, and note location, type of failure, and any necking of the bar.
16. Evaluate a reinforcement splice sample in fatigue loading from + 173 MPa to - 173 MPa for 10,000 cycles. Use a sine wave form at 0.5 Hz for #36, #43, #57 bars and at 0.35 Hz for smaller bars. If failure has not occurred at the end of 10,000 cycles, increase axial tensile load to cause failure in the sample.
17. Record load, and note location, type of failure, and any necking of the bar.
18. Measure the strain of the bar on the side of the splice away from the failure. Calculate the percent strain by

subtracting the original punch mark spacing from the final punch mark spacing and dividing by the original punch mark spacing, then multiply by 100.

Percent strain =

$$\{ L_{\text{final}} - L_{\text{original}} / L_{\text{original}} \} \times 100$$

19. Report this as the “percent strain”.

**PART III. CONTROL REINFORCEMENT BAR  
TEST (Standard Specification Section 52 -  
1.02A)**

1. Control bars must be from the same heat or lot number and should be cut from bar adjacent to the splice location. For strain measurement, mark reference points along the length of the reinforcing bar. Reference point spacing shall be 200 mm . Intermediate divisions are optional. See ASTM A370, Section 10.
2. Mount the control bar in the test machine.
3. Apply an axial tensile load to the test specimen sufficient to cause failure.
4. Note yield point (by the drop of the beam or halt in the gage of the testing machine), record load at yield and note maximum load.
5. Report maximum load attained as “maximum test load.”
6. Calculate the yield strength and maximum tensile strength by dividing each load by the nominal ASTM cross sectional area of the reinforcement bar. Report these as “yield strength” and “tensile strength” for the control bar.
7. Measure the strain of the bar away from the failure by measuring the spacing between reference points somewhere other than where the bar broke. Calculate the percent strain by subtracting the original punch mark spacing from the

final punch mark spacing and dividing by the original punch mark spacing , then multiply by 100.

Percent strain =

$$\{ L_{\text{final}} - L_{\text{original}} / L_{\text{original}} \} \times 100$$

8. Report this as the “percent strain”.

**D. NOTES**

1. Use the rate of loading for both the “slip,” the “maximum test load,” and the “Control Bar” determinations as specified in the standard test method outlined in ASTM Designation: A-370, Sections 11-13.
2. The measured strain, as determined by this test procedure, is defined by ASTM E6. It is axial strain due to tension force and consists of elastic and plastic strain.
3. Laser strain measurement method is an option for larger bars and couplers.
4. The engineer shall be responsible for checking the mechanical butt splices for compliance with the following portions of the specifications prior to submission for physical testing:
  - a. Splice components meet manufacturers published data for configuration, dimensions, and materials.
  - b. Obtain mill certificate information on reinforcement bars used to make the splice.
  - c. Splice components/methods meet manufacturer’s quality assurance requirements.

- d. Threaded components meet sleeve or lock nut torque requirements as per manufacturer's specifications.
- e. The number of samples required for production/job control tests shall be as stated.
- f. Sample length including splice shall be 1.2 m for #25 bars and below; 1.8 m for above #25 bars, with the splice at midlength.
- g. As required by Standard Specification, reinforcing bar alignment across the splice must be straight to within 7 mm in 0.9 m of length.

#### **E. HAZARDS**

The test samples are heavy and may contain sharp edges or burrs. Use gloves when handling the specimen, and use an overhead crane or testing machine power crosshead for inserting the #43 and #57 specimens into the test machine jaws. Premature failures may involve brittle fractures and ejection of portions of the test specimen. Keep personnel out of the immediate vicinity of the test machine as much as possible and use a safety screen.

#### **F. REPORTING OF RESULTS**

Document results of tests with appropriate comments and notations of defects on Form TL-0610. Report results in formal form (as complying or not complying with specifications) on Form TL-6039.

#### **G. SAFETY AND HEALTH**

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

#### **REFERENCES:**

**ASTM Designations A-370, A-615, and A706**

**End of Text (California Test 670 contains 4 pages)**

## **ADDENDUM A - LASER EXTENSOMETER**

### **A. SCOPE**

The laser extensometer is used to measure reinforcement bar or reinforcement bar splice sample strain without mechanical connection. This optical method for measuring sample strain uses a laser light beam to sense the angle change between two reflective tape targets placed on the sample. From this angle the computer program determines strain

### **B. TESTING APPARATUS AND ACCESSORIES**

Equipment needed: Laser system including PC computer, plotter, printer, laser head & mounting brackets and support cart. Interconnecting cables.

Supplies needed: Reflective tape, wire brush, black spray paint or black marker pen, chart paper, and plotter paper.

### **C. TEST PROCEDURE**

1. Determine gage length to be measured and place reflective tape stripes on the bar.
2. Black out the area immediately adjacent to the tape to help define the gage mark.
3. Shield the reflective tape from falling scale from the rebar. This prevents interruption of the laser light signal which will default the test.
4. Check paper supply in printer.
5. Turn on computer, printer, plotter, and laser control head.\*

6. Hook up cables from computer to laser control head
7. Load reinforcement bar splice sample in the test machine.
8. Boot computer and load preliminary setup information.
9. Load sample information.
10. Load paper on plotter surface.
11. Setup the test machine for required loading method.
12. Start the computer data sequence along with the test machine loading initiation.
13. Observe the loading and strain plot on the computer monitor screen.
14. After proceeding to sample failure, initiate plotting of the load vs strain through the laser computer program.
15. From the computer program save the test data to the system harddrive.
16. Initiate printing of the test data through the computer program.

### **D. REPORTING OF RESULTS**

Present the two hard copies (printed data and load vs strain) as test results.

### **E. HAZARDS**

\*Keep laser emitter door closed except when verifying signal or testing. Laser can be harmful to the human eye and looking directly into the light source could damage eyesight.